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SOME ROTHAMSTED FIELD EXPERIMENTS.*

It is perhaps fortunate that the approaching centenary of the Broadbalk experiment at Rothamsted has stimulated the publication of a detailed report (1) on wheat studies carried out there, at a time when interest is growing rapidly in the question of the relative merits of farmyard and artificial manures. The Broadbalk experiment in particular has continued over a period sufficiently long to detect any progressive deterioration in the crop, resulting from the continuous use of artificial fertilizers. The report is of particular interest, since it includes not only the continuous wheat experiments themselves but also a comparison with a variety of rotation experiments and with ordinary farming methods at a variety of stations.

The Broadbalk wheat field was last year harvested for the ninety-seventh time in succession, and this is the third discussion which has appeared during that time. On the first occasion (1893) the first 50 years were reviewed by Lawes, the founder of Rothamsted, and his collaborator Gilbert, and on the second by A. D. Hall in 1905. Since 1919, the scope of the experiment has been widened considerably, and in particular the application of statistical methods not previously available has enabled much more information to be extracted from the existing data.

The Broadbalk field is divided into strips each of which annually received the same manurial treatment, different from that in other strips. There is no obvious important trend in fertility across the field; the soil is, in fact, everywhere rather poorly adapted to wheat cultivation, as evidenced by the relatively low yield. Originally set up to disprove Liebig's theory that plants receive all their nitrogen from the air, many valuable data have been accumulated on the relative effectiveness of farmyard manure and a range of artificial fertilizers. It was early demonstrated that addition of nitrogen to the soil markedly increases the yield of grain and straw but that minerals are also necessary. For grain production, sodium nitrate is considerably more effective than ammonium sulphate in a

* Abridged from an article by R. D. Preston in *Nature*, Vol. 147, No. 3732.

(1) Sir E. J. Russell and D. J. Watson, Imperial Bureau of Soil Science, Technical Communication No. 40. The Rothamsted Field Experiments on the Growth of Wheat, 1940, 7*s*. 6*d*.

single dressing but not so much with a double dressing. For straw production sodium nitrate is always decidedly the more effective, and for both straw and grain spring application is preferable to autumn, due probably to less leaching from the soil. Levels of supply well above those in ordinary practice give greater yields. Perhaps the most important point in this connexion is that farmyard manure has only 44 per cent. of the efficiency of sodium nitrate, and only 50 per cent. of that of ammonium sulphate, when the artificial manures are added with complete minerals. Potassic fertilizers increase the yield both of straw and grain, an effect which is diminished by phosphate deficiency. This higher efficiency of artificial fertilizers does not appear to be offset by any progressive deterioration in the crop. During the period 1852-1918 the annual diminution in yield, eliminating random variations, was certainly lowest with farmyard manure (0.1 per cent. of mean yield), but this was closely followed by the plot with complete artificials (0.26 per cent.). The highest rate of deterioration was found in the plot receiving nitrogen and phosphate without potassium, where it amounts to one per cent. It is interesting that on the unmanured plot, though yields fell from 20 bushels per acre to ten in 20 years, they have not fallen lower except when weeds have become prevalent; in fact, during recent years they have risen.

This annual deterioration is attributed largely to changes in soil composition. All the plots with the exception of the farmyard manured have lost carbon and nitrogen compounds, but though the soil in the farmyard manured plots is different from that in others as regards physical properties there is no evidence that this soil is better suited to the wheat plant. There is certainly no suggestion, as the years go by, of progressive injury by rusts or by insect pests, though 'eye spot lodging' is somewhat more common than on crops grown in rotation.

Apart from this slight steady deterioration, the so-called 'annual variations' related to weather conditions, chance variations in cultivations, &c., have also been studied in detail. The main causes of such variations in yield are almost solely connected with weather factors; contrary to general belief time of sowing has no observable effect. The defect of the Rothamsted climate for wheat is that rainfall is much too high. In general it may be said that injury due to rain is least in October and greatest in or about January, when each additional inch of rain reduces the crop by one or two bushels per acre. This effect of winter rainfall is to be attributed partly to a leaching out of nitrogen (and is therefore least marked with farmyard manure), partly to excessive growth of weeds and, at Broadbalk, partly to the already heavy nature of the soil. The rainfall effect accounts for about $\frac{1}{4}$ to $\frac{1}{3}$ of the total annual variation on most of the plots, though on the farmyard manured plots the effect covers about 40 per cent. of the total and is the most important single factor concerned.

The chief practical difficulty in continuous wheat cultivation is the fight against weeds. The time between harvesting one crop and sowing the next is short and is usually not suited to the effective killing of weeds, and control is complicated by delayed germination of some weed seeds (two to nine years or more). The relation between weed infestation and wheat yield is not simple, but it is proved that wheat is ill-fitted to stand up to the competition of weeds. Introduction of a fallow in order to eradicate weeds proved a success. The yield which had been deteriorating, jumped immediately to the original level; an effect which is perhaps all the more striking as it lasted only one year. The main points about fallowing appear to be that it enables control of weeds to be made and allows the formation of a better seed bed and soil conditions; it allows an accumulation of nitrogen which may be very considerable (rising in plots with minerals only to the level of one with minerals plus 86 lb. nitrogen as ammonium sulphate); it emphasizes the need for potash.

In 1930 an experiment on modern lines was begun at Rothamsted and at Woburn involving a six course rotation of both crops and treatment. The wheat follows clover, and the yields without added manure are so good that added nitrogenous fertilizers have no effect at either station. Additional potash slightly increases the yield (Rothamsted) or, like phosphates, has no effect. In normal rotation conditions at Rothamsted (the Norfolk rotation-swedes (manured), barley, clover, wheat) begun in 1848 the addition of manure to the swedes had no effect on the wheat for the first 20 years, though afterwards the yields on unmanured land deteriorated more than on the manured. When clover failed it was replaced by beans, and both crops were found better than fallow except on unmanured land. The yields on all plots were similar, and resembled the Broadbalk continuous wheat yields with farmyard manures. In a mangold, barley, beans, wheat rotation (Saxmundham, commenced in 1899), however, the increase in yield with nitrogenous manure is almost the same as on Broadbalk, and here again the effectiveness of farmyard manure is considerably less (30 per cent.) than that of sodium nitrate.

An analysis of the development and composition of the wheat plant as affected by fertilizers has produced results of no less interest. Up to a certain point increased nitrogen has no effect on the composition of the wheat plant or on its habit of growth, and this point can be carried to a higher level of nitrogen supply by giving potash and phosphates. Finally, however, a point is reached at which nitrogen is in excess;

the leaves become liable to fungus attack, the crop tends to lodge, and the straw remains green for a longer time and dries slowly at harvest. The variation of composition with season is much more marked than with manuring. Milling and baking tests show no significant effect of treatment on quality, and the recent claim that wheat grown with farmyard manure is of better nutritive quality than wheat grown with artificial fertilizers is not supported by the Broadbalk samples as regards vitamin B.

On one point these experiments at Rothamsted are especially conclusive. No amount of manuring and no elaborate care in cultivation will ever raise a second class wheat field into the first class.

THE AMAZON FLY UNDER DROUGHT CONDITIONS IN BRITISH GUIANA.

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Introduction.

During 1939-40 there was in British Guiana a severe drought extending over several months. From rainfall records of the past sixty years, it appears that in this country, on the coastlands at least, droughts occur at intervals of about fourteen years, being recorded previously in 1885, 1899, 1911-12, 1925-26. During such drought periods the rainfall is about three-quarters of the normal and conditions are extremely dry over months at a time.

On the coastlands of British Guiana there are normally two well marked wet seasons a year, from May to July and again from November to January, but in drought years the end-year rains fail and the mid-year rains, although never actually failing, may be somewhat deficient.

The average annual rainfall at the Botanic Gardens, Georgetown, for the 59 years 1880-1938 was 90.91 inches. In 1939 and 1940 the rainfall recorded at this station was 65.71 and 69.29 inches respectively. Following a wet year in 1938 (119.00 inches), there was a more than average rainfall between January and April, 1939, but the mid-year rains (May-July) of 1939, were some 9.14 inches below the average. This short wet season was followed by a hard dry season and the end-year rains failed almost entirely so that the rainfall from August to December, 1939, was only 10.75 inches, that is 18.95 inches below the average. This dry spell continued into 1940 and the rainfall from January to April was 6.92 inches or 20.19 inches below the average of 1880-1938. The drought broke with the mid-year wet season of 1940 which was almost normal with a rainfall of 31.39 inches (May 7.80 inches, June 13.54 inches, July 10.05 inches) against an average of 34.10 inches for these months. From this data it will be seen that for the period August, 1939 to April, 1940, there was recorded only 17.67 inches against an average of 56.81 inches for such months. Actually, the end-year rains of 1940 were also short but this has not been considered as it has no bearing on the survey now under consideration.

From the time of the introduction of the Amazon Fly into British Guiana in 1933 there has been no marked drought prior to that now recorded and it was considered that opportunity should be taken of the unusual conditions to examine the status of the insect when the drought terminated to ascertain what was the effect, if any, of such conditions on the status of the fly. The data now submitted is the result of such an examination undertaken in August and early September, 1940, some four months after the severe dry period had terminated.

Previous Surveys.

Since the introduction of the Amazon Fly into this country (1), (3), (4), occasional examinations have been made on sugar estates to confirm the presence of the insect and also the extent of parasitism it was effecting and so determine its status.

In 1935, two years after the introduction of the fly, Squire (5) carried out examinations which showed that it was still doing good work.

In 1937-38, a fairly extensive survey was undertaken by the writer (2), (3), the results of which were summarised as follows:—

"As the result of this survey it has been found "that not only is the Amazon Fly present in the "fields but that it occurred in 73 per cent. of the "fields examined. That in such fields the fly "was parasitizing an average of 16.0 per cent. "of the *D. saccharalis* population and 0.32 per "cent. of the *D. canella* population, and taken over "all the fields the figures were 13.7 per cent. and "0.23 per cent. respectively. The parasitism ranged "from 3.4 per cent. to 36.2 per cent. for 'Positive "Fields' and 2.0 per cent. to 35.6 per cent. in "'All Fields'. In 18.4 per cent. of 'Positive "Fields' the parasitism of *D. saccharalis* was "30 per cent. and over."

The position as shown in the 1937-38 survey was maintained in the 1939 as far as information is available and an examination at Pln. Lusignan, East Coast, Demerara, which estate was included in the 1937-38 may be taken as indicative. In

January, 1939, three fields, two plant canes and one ratoon, were examined on that estate and in these the parasitism of *D. saccharalis* were 47.0, 6.6 and 66.6 per cent. respectively (average of 40.0 per cent.); in two of the fields adult Amazon flies were observed. In none of these fields was there any parasitisms of *D. canella*.

Present Survey, 1940.

In 1940 another survey was undertaken primarily to ascertain the effect, if any, which the prolonged drought had produced on the status of the fly. The field examinations were carried out during August and early September when conditions were about normal, the drought having broken in the previous May. It is true that from May until the examinations were made in August there intervened some four months with fairly high rainfall in which conditions were to the advantage of the insect and would help it in recovering from any effects of the drought. This, however, would not alter the fact that the insect had passed through a prolonged period of deficient rainfall and would confirm its ability to withstand drought conditions and capacity to resume its previous status on the return of normal conditions.

The survey was undertaken on five estates, four situated on the East Coast, Demerara, and one on the West Bank, Demerara River. These estates were also included in the survey of the 1937-38 so that comparison of the two surveys is possible. Table I gives the results of the 1940 survey. From this it will be seen that of the 52 fields examined in 37 or 71.0 per cent. the Amazon Fly was present. Of the stalks examined 35.9 per cent. contained *Diatraea*, in the proportion of 34.2 per cent. *saccharalis* and 65.7 per cent. *canella*. The parasitism of *D. saccharalis* by the Amazon Fly was determined for "Positive Fields" as 42.9 per cent. and in "All Fields" as 23.3 per cent. (In 28.8 per cent. of the "Positive Fields" the parasitism of *saccharalis* was over 30 per cent.). In only one field (0.19 per cent.) was there parasitism of *D. canella* and this was only 4.0 per cent.

Table II gives the results of the 1937-38 survey for the same estates. In that instance it will be seen that 60 fields were examined of which 36 or 60.0 per cent. were "positive". Of the stalks examined 33.5 per cent. contained *Diatraea* in the proportion of 38.2 per cent. *saccharalis* and 61.7 per cent. *canella*. The parasitism of *D. saccharalis* by Amazon Fly was in "Positive Fields" 15.5 per cent. and in "All Fields" 12.6 per cent. In 13.9 per cent. of the "Positive Fields" the parasitism of *saccharalis* was over 30 per cent.

TABLE III.—RAINFALL ON SUGAR ESTATES AND BOTANIC GARDENS.

Months.	Pln. Lusignan.	Pln. Enmore.	Pln. Nonpareil.	Pln. Cane Grove.	Pln. Schoon Ord.	Botanic Gardens.	Botanic Gardens. Mean 1880-1938.
1939							
August	2.20	2.51	2.06	1.53	2.89	3.08	6.91
September	2.81	2.87	2.51	.60	1.22	2.43	2.95
October	.92	2.02	1.57	1.26	2.03	1.57	2.76
November	2.21	1.84	2.16	.66	1.72	1.39	5.45
December	2.13	1.14	1.86	2.37	2.25	2.28	11.63
	10.27	10.38	10.16	6.42	10.11	10.75	29.70
1940.							
January	3.99	4.42	4.17	4.70	5.21	4.58	8.83
February	.53	.32	.73	.50	.35	.67	5.73
March	.51	.45	.37	.32	.64	.64	6.31
April	1.67	.98	1.61	.81	2.07	1.03	6.24
	6.70	6.17	6.88	6.33	8.27	6.92	27.11
May	8.11	5.35	9.19	4.85	12.05	7.80	11.57
June	13.20	9.30	12.56	9.85	16.91	13.54	12.21
July	8.98	10.20	9.29	9.95	12.92	10.05	10.32
August	7.60	8.04	5.62	7.03	7.82	7.44	6.91
	37.89	32.97	36.66	31.68	49.70	38.83	41.01
Total	54.86	49.52	53.70	44.42	68.08	56.50	97.82
Mean 1933-38 ...	99.01	90.08	104.69	95.89	114.09	99.86	—

TABLE I.—AMAZON FLY SURVEY. 1940—RESULTS OF EXAMINATION OF SUGAR ESTATES.

Estate.		Date of Examination.	Fields Examined. Total.	Plants.	Ratoons.	Positive.	Negative.	Stalks Examined. Total.	Empty.	Diatraea. All Fields. Total.	Sac.	Can.	Positive Fields. Total.	Sac.	Can.	Other Causes.	Amazon Fly Current Parasitism *D. Saccharalis*. All Fields.	Positive Fields.
Lusignan	No. ...	29 Aug.	12	7	5	11	1	1,668	843	751	208	543	679	194	485	74	52	52
	% ...	2 Sept.							50.4	45.0	27.6	72.2	40.7	28.2	71.4	4.4	25.0	26.8
Enmore	No. ...	27 Aug.	12	7	5	6	6	1,457	819	614	68	546	294	32	262	24	9	9
	% ...	28 Sept.							56.2	42.1	11.0	89.0	20.2	10.9	89.0	1.6	13.6	29.1
Nonpareil	No. ...	9 Oct. ...	4	4	—	3	1	313	188	115	33	82	92	31	61	10	12*	12
	% ...								60.1	36.7	28.7	71.3	29.3	33.6	66.3	3.2	36.4	38.8
Cane Grove	No. ...	30 Sept....	12	12	—	5	7	1,447	814	551	238	313	231	101	130	82	17	17
	% ...	4 Oct. ...							56.3	38.1	43.1	56.7	15.9	43.7	56.2	5.6	7.4	18.3
Schoon Ord.	No ...	20/23	12	6	6	12	—	2,006	1,535	446	301	145	446	301	145	25	106	106
	% ...	Aug.							76.5	22.2	67.4	32.5	22.2	67.4	32.5	1.2	35.2	35.2
Total ...		...	52	36	16	37	15	6,891	4,199	2,477	848	1,629	1,742	659	1,083	215	196	196
Per cent. ...		...	—	69.2	30.7	71.0	29.0	—	60.9	35.9	34.2	65.7	25.3	37.9	62.1	3.1	23.3	42.9

**D. Canella* was parasitised in only one field at Nonpareil.

TABLE II.—AMAZON FLY SURVEY, 1937-38—RESULTS OF EXAMINATION OF SUGAR ESTATES.

Estate.		Date of Examination.	Fields Examined. Total.	Plants.	Ratoons.	Positive.	Negative.	Stalks Examined. Total.	Empty.	Diatraea. All Fields. Total.	Sac.	Can.	Positive Fields. Total.	Sac.	Can.	Other Causes.	Amazon Fly Current Parasitism *D. Saccharalis*. All Fields.	Positive Fields.
Lusignan	No. ...	10/14	12	6	6	6	6	1,778	790	620	143	477	304	112	192	368	25	25
	% ...	May							44.4	34.8	23.1	76.9	17.0	36.8	63.0	20.7	17.5	22.3
Enmore	No. ...	19/21	12	4	8	5	7	1,811	1,044	655	291	364	426	227	199	112	28	28
	% ...	April ...							57.6	36.1	44.4	55.6	23.5	53.2	46.7	6.2	9.7	12.3
Nonpareil	No. ...	29 April ...	12	3	9	9	3	2,291	1,235	714	293	421	562	242	320	342	34	34
	% ...	5 May ...							53.9	31.1	41.0	59.0	24.5	43.0	57.0	14.9	11.6	14.0
Cane Grove	No. ...	25 Feb. ...	12	6	6	9	3	1,886	1,216	590	134	456	443	116	327	80	24	24
	% ...	31 Mar. ...							64.5	31.4	22.7	77.3	23.4	26.2	73.8	4.2	17.9	20.7
Schoon Ord	No. ...	7/10	12	6	6	7	5	1,919	1,153	666	379	287	438	317	121	100	45	45
	% ...	Dec.							60.1	34.7	57.0	43.0	22.8	72.5	27.5	5.2	11.9	14.2
Total ...		...	60	25	35	36	24	9,685	5,438	3,245	1,240	2,005	2,173	1,014	1,159	1,002	156	156
Per cent. ...		...	—	41.6	58.3	60.0	40.0	—	56.8	33.5	38.2	61.7	22.4	46.2	53.3	10.3	12.6	15.5

The rainfall at the estates included in the present survey for the thirteen months August, 1939 to August, 1940, is given in Table III, together with that of the Botanic Gardens, for the same period, as well as the means for the 59 years 1880-1938 have been added for comparison.

Although the rainfall recorded at these places varied considerably, it was in no instances more than 60 per cent. of the mean annual rainfall for the years 1933-1938. What is more striking, however, is that of the nine months of actual drought, from August, 1939 to April, 1940, the rainfall in none of these places was more than 19 inches for the period (18.38 inches at Schoon Ord) and at one (Cane Grove—12.75 inches), it was under 13 inches. At the Botanic Gardens the mean rainfall for the nine months' period August to April for the 59 years 1880-1938 was 56.81 inches while for the same period in 1939-40 it was only 17.67 inches or 31.1 per cent. of the mean. The rainfall on the estates in the same period was between 22.4 per cent. and 32.2 per cent. of the mean of the Botanic Gardens.

Summary and Conclusions.

In British Guiana there was a severe drought during 1939-40 in which the rainfall over nine months August, 1939 to May, 1940, was only 17.67 inches or 31.1 per cent. of the mean for the same period 56.81 inches of the previous 59 years 1880-1938.

A status survey of the Amazon Fly was undertaken in the following August to determine what had been the effect of this prolonged dry period, if any, on the fly.

A previous status survey of the fly undertaken in 1937-38 was available for comparison.

From a comparison of the data of the two surveys it is evident that the Amazon Fly has maintained its position as a parasite of *D. saccharalis* since its introduction into British Guiana in 1933 and that during 1939-40 there has been no indication that this status has diminished.

The prolonged drought which occurred from August, 1939, and April, 1940, during which the rainfall in the localities examined ranged between only 12.75 and 18.38 inches, has not affected the status of the fly as a parasite of *D. saccharalis* and it is evident that under British Guiana conditions at least, the fly can adapt itself to such prolonged dry periods.

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HUMUS AND THE FARMER.

Under this title, Mr. G. V. Jacks, deputy-director of the Imperial Bureau of Soil Science, Rothamsted, recently delivered a lecture to the Royal Society of Arts, in which he dealt with the origin of humus, its functions in the soil, and how far shortage of humus-producing organic manures can be made good by other means. Humus is derived from decaying plant and animal residues; it acts by promoting a granular structure in the soil, by supplying energy to micro-organisms, and by providing plant nutrients. In the natural state, vegetation supplies the kind of humus in which it best thrives, but cultivated crops do not supply such an optimum product, so that human intelligence and skill are needed to bring about that biological balance in the soil which is the essence of fertility. A grass cover is especially valuable for producing the granular soil structure that is needed by our basic crops, for these are also grasses, perennial for animal and annuals (cereals) for human consumption.

When a soil has lost its virginal fertility by long-continued arable husbandry, it is best rejuvenated by laying it down to grass for a shorter or longer period. When our ancestors first enclosed the open fields, they nearly always put them down to pasture. Later, when clovers and roots were introduced, mixed farming became possible, animals could be kept throughout the winter and their manure conserved for the land. Today much stress is laid on the necessity for rejuvenating our cultivated soils by ley farming or alternate husbandry. But the use of grass and plant and animal residues does not suffice in the absence of human skill and intelligence. These attributes became manifest when drilling was first substituted for broadcasting seed, when the art of drainage was developed, and when artificial fertilizers were invented. Such fertilizers can provide all the nutrients plants require, though they cannot produce the granular soil structure effected by humus. Plant humus, on the other hand, will not make a soil fit for permanent agriculture, for a human society makes far greater demands on the soil than does any natural plant community; nevertheless, every scrap of waste organic matter which the land produces should be returned to it.—(*Nature*, 1941, Vol. 147, p. 354.)

AGRICULTURE IN THE DUTCH WINDWARD ISLANDS.

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Introduction.

General Features.

The Dutch Windward Islands consist of St. Maarten (The Dutch part of the Dutch and French island of St. Martin), Saba and St. Eustatius, lying between the British West Indian islands of St. Kitts and Anguilla. Owing to their proximity to the "Leeward" group of the B.W.I., they are often incorrectly referred to as the Dutch Leeward Islands. However, the translation of their Dutch designation, *i.e.* "Bovenwindsche", is "Windward". Together with the Leeward ("Benedenwindsche") islands of Curaçao, Aruba and Bonaire, which are situated off the coast of Venezuela, they form The Netherland territory ("Gebiedsdeel") of Curaçao.

The three islands are administered by a "Gezaghebber", a Senior Administrator, with headquarters in St. Maarten. "Onder-Gezaghebbers" represent him in Saba and St. Eustatius. The whole territory is under the control of a Governor-General, resident in the island of Curaçao. One elected member represents the three islands in the Colonial Council, which sits in Curaçao. These islands are altogether dependent upon funds from Curaçao for the maintenance of administrative and civil services. They are almost entirely tax free and recently the only duty, *i.e.* that on wines and liquors, has been removed. The Royal Netherlands Steamship Co., with the help of a substantial Government subsidy, maintains a regular fortnightly service between the Leeward and Windward groups and the island of St. Kitts.

The areas and approximate populations with highest mountain peaks and rainfalls are given by Ballou (1) in Table 1, together with similar data for neighbouring islands:

Table 1.

Island.	Area in square miles.	Population.	Height in feet.	Rainfall in inches.
Montserrat ...	32	12,000	3,000	57
Nevis ...	50	13,000	3,600	52
St. Kitts ...	68	26,000	3,700	60
St. Eustatius	9	1,000	2,000	40
Saba ...	5	1,200	3,000	40
St. Martin—				
French ...	20	4,000	1,500	40
Dutch ...	18	2,500	—	—
Anguilla ...	35	4,000	200	36

The highest peak in St. Maarten is 344 metres (about 1,130 ft.) high and the average recorded rainfall for the years 1887-1936 is 40.80 ins.

A good market, which has not yet been fully taken advantage of, exists in the Leeward group for many commodities that can be produced in St. Maarten, Saba and St. Eustatius. Since 1933 the Government has granted free freight to certain cattle shipped from the Windward to the Leeward group and recently this free freight has been extended to all agricultural produce shipped through the recognized agricultural societies. One such society exists in each of the three islands.

Many conflicting opinions as to the agricultural possibilities of these islands have been expressed by lay visitors and officials. In many cases these views have been either too optimistic or too pessimistic depending on whether their visits coincided with the rainy or dry season. In contrast, Ballou wrote in 1934 (2)—"With reference to the possibility of promoting the prosperity of the Dutch Leeward (*Windward*—C.A.S.H.) islands by means of agriculture, I must say that I see very little hope of any *considerable* degree of prosperity being brought again to these islands in the near future. It should, however, be possible to improve on existing conditions *very considerably* (italics not in the original). If the conditions of living are to be improved at all it appears certain that the improvement must be brought about by attention to agriculture as there seems to be no other line of industry likely to be developed in these small islands."

Soils.

According to Ballou (1)—"On the whole, the soils appear to possess high inherent fertility and not to be in need of manuring". Perhaps the insertion of the word "immediately" between "to be" and "in" would convey his meaning more exactly, because it can be certain that he would not wish the population to get away with the idea that cropping could be carried on for any length of time without the lands being manured.

The above quotation, including the suggested insertion, is entirely in agreement with the writer's observations over a period of six years, and contradicts a popularly expressed belief that the soils of St. Maarten are infertile. In the writer's experience, on most St. Maarten soils the response to medium rainfall is immediate and often prolific, provided such soils are properly worked. Unfortunately rainfall is often low and the thorough preparation of land in St. Maarten is still very much more the exception than the rule. The soil is stony and far more difficult to work than that in Saba and St. Eustatius, and it is not easy to persuade the peasant that thorough cultivation pays.

Referring also to St. Maarten Ballou wrote, (1) that "potash is quite abundant". In this connection it is interesting to note that the results of two well replicated manurial trials with maize

carried out recently at the Experiment Station, St. Maarten, showed that a moderate dressing of a complete artificial manure rich in potassium resulted in a decrease in yield over the controls.

Labour.

A view often expressed in responsible quarters is that the labourer in these islands is fundamentally lazier than similar labourers in the B.W.I. The writer is not in agreement with this opinion. It has to be borne in mind that conditions for agriculture are hard (especially in St. Maarten) and easier means of obtaining a livelihood have for long existed in the Leeward group and elsewhere. The choice of an easier way is not necessarily a sign of laziness. Opportunities of earning a livelihood in other islands are, however, becoming fewer and fewer and more of the population may be forced to turn to agriculture. In spite of the other attractions, by no means all of the population, even in St. Maarten, has been averse to agriculture. The writer has been struck by the determination with which some of the older cultivators persist with their crude methods in their struggle to eke out a living from the land.

It seems that the failure of agricultural projects in these islands have often in the past been unfairly blamed on the laziness and intractability of the population, while there is no evidence to show that the projects were rigorously tested over a sufficiently long period *before* being generally introduced. Such tests might have revealed the inherent impracticability of many of the schemes, or at least indicated the minimum conditions essential to success.

Industries.

The manufacture of sugar and rum was carried on in St. Maarten and St. Eustatius during the last century and Sea Island cotton was exported up to as late as 1922. Without going into the causes of the discontinuance of these industries, the writer is of the opinion that had they been kept alive, in however moribund a condition, it would probably have been possible, with the substantial financial assistance which the Curaçao Government has been in a position to give in the last decade or so, to resuscitate the sugar and Sea Island cotton industries in St. Eustatius and, with the cooperation of the French authorities, the Sea Island Cotton industry in St. Maarten. The re-establishment of such industries in these islands under present conditions, although not outside the bounds of practicability, offers very serious difficulties, not the least of which would be brought about by the fact that the peasants have got out of the habit of cultivating these crops. Now it would not only have to be a question of introducing a new variety or a new cultural procedure, but of entire re-education.

Establishment of Agricultural Stations.

Following recommendations made by Ballou in a report to the Curacao Government, after his visit to these islands in 1934, a Government agriculturist was appointed to the three islands in 1935. In September of that year an Experiment Station was established at headquarters, St. Maarten. In August, 1937 a similar Station commenced work in St. Eustatius. This was abandoned and re-established on a new site in 1939. In 1938 work was started on a small station in Saba. The stations in St. Eustatius and Saba are under the direct supervision of assistant agriculturists. An important change was made when, in 1938, the local Agricultural Department was made a part of the Department of Accountancy, Social and Economic Affairs with headquarters in Curaçao.

Prior to the appointment of Government agricultural officers, agricultural and cattle-raising associations were set up, with liberal financial assistance from the Government, in each of the three islands. It is regrettable that the establishment of the Agricultural Department and an experimental programme of some duration had not preceded the formation of these associations, or at least the granting of substantial financial aid to them. The help and guidance of an experienced Department would very likely have resulted in better use being made of the Government grants than has been the case. The Agricultural Department did not come into the picture until the initial enthusiasm of the association members had waned and grants had been seriously depleted with little or no *lasting* benefit as a result. The consequent disappointment and disillusionment has not made the work of the Department any easier. The agricultural officers in St. Maarten and Saba are now secretary-treasurers of the associations in their respective islands.

St. Maarten.

In 1934 Ballou wrote (1)—"There are no satisfactory records of the exports of agricultural produce from St. Martin. At the present time the livestock is shipped entirely from the French port of Marigot."

Table 2 gives the exports to the Leeward group of all agricultural produce, cattle, &c., shipped by the Agricultural Department from the Dutch port of Philipsburg during the years 1938-1940:

Shipments are made chiefly for members of the agricultural and cattle-raising association, who are the only persons eligible for free freight. Practically all produce for the open market is shipped now through the Agricultural Department, which also looks after the paying out to individual shippers. No exact figures are available for much miscellaneous agricultural produce shipped through other channels to friends and relatives.

The appearance of items such as tomatoes, onions, carrots, &c., on the 1940 export list, albeit in small quantities, indicates that the experimental work started in 1935 is beginning to show some results. Hay, which has suddenly come to be of considerable importance, is made by sun-drying Para and Guinea grass. It is put up in 50 kilogram bales. The first bale for export was made on Estate Bellevue, which is situated partly on French and partly on Dutch land.

Table 2.

	1938	1939	1940
Bulls and steers	39	132	99
Cows ...	29	2	18
Sheep ...	267	559	764
Goats ...	91	150	250
Pigs ...	Nil	17	89
Mules ...	,,	Nil	1
Hay kgs.	,,	37,865	203,950
Onions ,,	,,	1,260	1,625
Sweet potatoes ,,	,,	Nil	7,319
Limes ,,	,,	,,	590
Tomatoes, beets and carrots ,,	,,	,,	410
Misc. vegetables, fruit, &c. ,,	,,	,,	825
Poultry ...	,,	,,	22
Eggs ...	,,	,,	360
Brooms ...	,,	,,	7
Net Returns (exact amount paid out to shippers) Fls.	4,946.18	14,971.89	30,293.55
approx. £	639	1,936	3,919

St. Eustatius.

The "principal exports from St. Eustatius during the 10-year period, 1913-1922" and their value are given in Table 3 (1).

Table 3.

Exports.	Mean Annual Value.	
	In Guilders.	In Sterling.
		£
Cotton	36,000	3,000
Sweet potatoes ...	2,000	167
Yams	3,770	317
Stock	3,954	328
Charcoal	95	8

The nature and conservatively estimated net value of exports for the 3-year period 1938-1940 are shown in Table 4. The estimate is based on the actual prices paid for some of the undermentioned produce, which was shipped through the Agricultural Department :—

Table 4.

Exports.	Mean Annual Value.	
	In Guilders.	In Sterling.
		£
Sweet potatoes ...	11,070	1,433
Yams	1,425	184
Misc. vegetables ...	580	75
Charcoal	224	29
Stock	3,068	398
Poultry	496	64

The absence of cotton from the latter table and the increase in the exports of sweet potatoes are noticeable.

As long as conditions in the Leeward Group remain much the same as they are now, it should be possible in the near future for the export value of sweet potatoes and yams to equal or exceed the given former value of cotton exports. These commodities are consumed by the relatively large West Indian population in Curaçao and Aruba. The demand is much greater than the supply from St. Eustatius. Quantities are imported from outside the colony.

A work of foremost importance has been the initiation of a land settlement scheme. Surrounding the recently established Experiment Station, on which houses for the Assistant Agriculturist and Foreman, an Office, storerooms, &c., have been erected, 13 selected cultivators have already been settled. Each family occupies a small four-roomed concrete building situated on about 5 acres of land. Two adjacent wind-mills supply ample water for the cattle not only of the settlers, but also of the whole district.

The preoccupation of the Department with the settlement scheme and the fact that the site of the Experiment Station had to be changed have resulted in experimental work being retarded. However, preliminary trials with the newly introduced sweet potato variety B44 indicates that it is vastly superior to the standard "Round Hill", which has been deteriorating rapidly in recent years.

Trials with Sea Island cotton have also been carried out. Pedigree seed from the Montserrat station has been supplied for trials by the W.I. Sea Island Cotton Growing Association on the understanding that there would be some cooperation with the British authorities in the control and prevention of pests. This would remove a menace to the cotton industry of St. Kitts, with which island there is a regular traffic. Destruction of cotton plants throughout the island was carried out in 1939 and 1940, and Plant Protection legislation is being considered as a possible eventuality. A recent trial (1940-1941) on 2¼ acres of somewhat wind-swept land gave a yield of 134 lbs. clean lint per acre under unusually dry conditions. No pink bollworm or other pests were observed. The absence of a market may well prove to be the prohibitive factor against the re-establishment of the industry.

Saba.

Saba is in many ways unique. Among the white population, the women do no agricultural work, but the men have a very strong attachment to the land. They take great pride in their small gardens perched on steep hillsides and most of these are kept in splendid condition. It is not unusual for a native of Saba, who has made good elsewhere, to return to the hand cultivation of his hillside garden.

A good proportion of the food is grown locally. In the writer's opinion, if the diet is not sufficiently well balanced, it is due more to insufficient dietetic rather than agricultural knowledge.

The scale of agricultural operations is limited owing to the paucity of arable land, and exportation of any produce involves the difficulty of getting it down the steep paths to the sea.

The value of the small quantities of stock and produce exported for members of the agricultural association amounted to fls. 846.15 (about £109) in 1939 and fls. 1302.59 (about £169) in 1940, of which fls. 150.00 and fls. 482.04 respectively were for English potatoes. The total English potato crop in 1940 amounted to about 500 barrels. A potato of fairly good flavour is produced, but yields are low. The average yield for one planting in 1940 was about 4 barrels to 1 of seed; the highest recorded yield being 9 to 1.

The tiny experiment station has concerned itself chiefly with trials of numerous varieties of garden crops. Many varieties that fail completely in St. Maarten and St. Eustatius do well here under the somewhat milder climatic conditions. Peach trees, strawberries and raspberries are being tried in protected spots about 3,000 feet above sea level.

While it is hardly possible that the export of ordinary bulky agricultural commodities can ever be of much importance as a source of island income, it would seem that the establishment of a "Cooperative", similar to that operating successfully in St. Thomas, Virgin Islands, has distinct possibilities. Such a "Cooperative" would offer scope for the activities of the female population that largely preponderates. A somewhat similar idea was put forward by Ballou in 1934 (2).

Future Outlook.

As long as the islands of Curaçao and Aruba continue to enjoy their present prosperity the value of exports of agricultural produce and stock to those islands should increase steadily. With the Government persisting in its policy of aiding agricultural experimental work, there is reason to believe that some industry or industries will eventually be established, which would prevent producers being entirely dependent upon the Leeward Islands market. The extension work, which has already made some headway, should result in a much larger quantity of food being grown for home consumption. Little progress, however, will be possible except by the slow and laborious method of education, in its widest sense, and by the consolidation of small and, at first, seemingly unimportant gains.

One of the arguments to be most guarded against is the often recurring one that the cultivation of a certain crop, or a certain cultural practice, "will not pay". This usually means that it will be unprofitable under a given estate system paying labourers a certain wage. The cultivation of most crops will, indeed, no longer pay the estate-owner, who relies solely on paid labour, under present conditions in the Dutch Windward Islands, but the consideration with peasant agriculture is not "will it pay?", but can it be successfully introduced, and if so, will it result in a *better* livelihood for the average peasant? This question can only be answered by one who thoroughly understands the mentality and way of life of the particular peasantry. The above must not be taken as advocating that figures should not be adhered to as closely as possible in experimental work. Such adherence is essential if there is to be some reliable basis to work from, but in carrying out trials on Government stations or farms, a financial loss or gain is not in itself a sufficient indication as to whether or not a particular crop or method should be introduced to the peasantry.

If the present agricultural associations are to serve the useful purpose for which they are intended, they should aim at becoming largely self-helping. It is not intended by this to suggest that financial assistance from Government should be withdrawn or withheld, but that such assistance should only be given if the Government is satisfied that it will help towards the above-stated goal.

Acknowledgments.

The writer wishes to thank His Excellency the Governor of Curaçao and Mr. L. F. Jansen, Director of the Department of Accountancy, Social and Economic Affairs, for permitting the use of certain official figures and for approving the publication of this article.

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CONTROL OF MOULDS ON CITRUS FRUIT.

J. E. van der Plank, *et al.* (*J. Pom. & Hort. Sci.* 18, 135; 1940), have described experiments on the use of paper impregnated with o-phenylphenol for wrapping citrus fruits. These wraps successfully reduced the number of fruits infected with *Penicillium digitatum*, *P. italicum* and *Trichoderma lignorum*. 5 mgm. o-phenylphenol per sq. ft. of paper reduced infections by a half; 9 mgm. (0.44 per cent. of the paper weight) gave 87 per cent. reduction, but amounts in excess of this caused injury to the rind. Lemons were less easily injured than oranges or grapefruit. Glyceride oils incorporated in the wrap allowed the use of more preservative without causing injury, and did not reduce the efficiency of the preservative. The wraps are odourless and colourless. They do not taint the fruit or reveal the presence of preservative, which has the advantage of being cheap. — (*Nature*, 1940, Vol. CXLVI, No. 3698, p. 370.)

CONSIDERATIONS REGARDING STOCK FARMING IN TRINIDAD WITH SPECIAL REFERENCE TO THE FRESH MILK INDUSTRY.

By E. Harrison, C.M.G.
(*Professor of Agriculture, Imperial College of Tropical Agriculture*).

In Trinidad, the number of horned stock at 25,000 head is low compared with the number of the population, there being about 425,000 souls, of whom some 100,000 live in three large towns. In addition to cattle there is a steadily increasing number of water buffalo, but these are of a working type mainly.

The number of cows of mature age included in the 25,000 aforesaid cannot be many, certainly not more than 12,000 head and many of these are hardly worthy of the name "dairy cow." The number of animals kept as we understand dairy cows should be kept is around 2,000 head. When it is considered that the average annual import of condensed, dried or preserved milk amounts in value to $860,000 or 84,000 cwt. equal to a minimum of 2,772,000 gallons of fresh milk per annum or 7,600 gallons per day, it can be readily understood that there is more than the possibility of a large unsatisfied market for fresh milk. Admittedly preserved or dried milk is more convenient for large numbers of the population yet the steadily increasing European population plus a certain rise in the standard of living of the rest must inevitably result in the accelerated development of the fresh milk industry in the Island.

Cheese and butter are not made locally; these are imported mainly from Canada. Of cheese 7,000 cwt. valued at $130,000 and butter or substitute fats, 18,500 cwt., value $492,000 were imported in 1939. There is a volume of experience relating to the behaviour of breeds of dairy cattle introduced, and, under reasonably good conditions of housing, feeding and management, it has been found that the pure bred and the very high grade—15/16ths—do not perform so well as those between ½ and 7/8ths bred, in fact, ¾ bred is usually considered high enough. Whether under more artificially controlled conditions of temperature and humidity, pure bred or very high grade cattle would perform up to expectations is not known because such conditions have not been tried. As there are several very good ¾ breds doing excellently as milch cows the necessity for trial of utterly artificial conditions has not arisen—possibly it would never be an economic method here. Thus at the outset we have a problem of breeding, the 3/8ths Zebu, 5/8ths European strain has not been tried deliberately.

The common stock of the country is descended from a mixture of European strains, some of them carry marked traces of Indian (Zebu) blood, but it is all acclimatised. Unfortunately, on account of the fact that conditions in the Island would not suggest even fair reasonable cattle country, the common stock exhibits extreme variableness, and, on account of the natural unsuitability of the land coupled with feeding conditions, stock shows degeneracy. As a rule, however, those animals which milk reasonably well, say 450 gallons per lactation are in demand by established dairy men and by those who are expanding or starting up dairy herds, so that the market is drawing out of the mass of common stock and steadily aggregating in herds, a proportion of the cattle which exhibit milking tendencies.

When these cattle get into dairy herds, as a rule they are bred to better class bulls, many of them imported pure bred, or locally born pure bred. But high grade bulls of Zebu origin are also used. In an endeavour to raise the breed standard of calves born, Government, in addition to breeding good bulls for sale, has pure bred stock standing for service at what are called "Breeding Centres".

So it may be understood that there is an undercurrent of cattle improvement, the only ideal aimed at being an improved milk yield. There is no properly understood and aimed at ideal of conformation; this is to some extent to be expected where crossbreeding for vigour and selection for milking capacity are the main methods by which the objectives are reached.

Equally there is a lack of knowledge regarding the value and method of use, of the available locally grown foodstuffs, as also the preservation or storage of such foodstuffs. The method of ensilage has been tried and is not now much used; hay cannot well be made and preserved naturally and roughage is usually grass cut and fed green. In addition, the keeping of grain is attended with loss due to weevil infestation and mustiness. Dairy farmers must come to realize that too much dependence on imported foodstuffs is undesirable, at the same time the economy of the production of cattle feeding stuffs locally is a problem. By and large it may be stated that all the roughages used are produced locally, together with one concentrate namely coconut meal in quantity sufficient for rations. Maize supplies require supplement from abroad; small quantities of pulse and milling offals are available in the country, but the better grade concentrates such as soya bean meal, wheaten bran, linseed meal, groundnut cake, cotton seed meal, and practically all calf meals are imported.

Any system of management and feeding which will reduce the need or demand for imported foodstuffs is obviously of great importance, as the following figures will indicate. It is impossible to state what proportion of feeding

stuffs in the first category are for direct consumption by human beings and of the remainder what proportion is utilised in the feeding of cattle, for there are horses, mules, pigs and poultry in the Island, but the total figures are given as a matter of interest.

(1) *Foodstuffs, Imported.*

	1939		1940	
	cwt.	value $	cwt.	value $
Maize and maize meal	33,000	61,000	20,000	53,000
Oats ...	40,000	80,000	33,000	84,000
Peas and beans (dry)	47,000	183,000	43,000	247,000
	120,000	324,000	96,000	384,000

Oats of course cannot be grown in the Island.

(2) *Feeding stuffs for Animals.*

	1939		1940	
	cwt.	value $	cwt.	value $
Cereal by-products	672	18,000	572	19,000
Oilseed cakes	2,850	32,000	2,272	127,000
Mixed foodstuffs	510	21,000	1,313	90,000
Meals and other non-specified	450	30,000		
	4,482	201,000	4,157	236,000

One would deduce that approximately 170,000 dollars worth of cattle feed is imported, and mainly for the feeding of dairy cattle. A rough check has been contrived by examining the expense side of the concentrate rations of several commercial dairies and one can feel satisfied that the upkeep of cattle in the Island cost around $170,000 for imported foodstuffs during 1939, practically all of this representing foreign exchange.

Since then naturally, due to rises in cost and increasing difficulty of supply, the quantity of foodstuffs imported for this purpose has fallen slightly, and rations requiring ever increasing proportions of locally produced foodstuffs are being used at present.

I do not wish anyone to run away with the idea that it is at all possible for the dairying industry altogether to eliminate imports of foodstuffs for the use of dairy cattle, but I do wish to stress that the industry is developing, and concurrently we must develop our local foodstuff resources and find out where we are failing to use these feeds advantageously and economically.

To this end a steady enquiry and observation has been carried out by post-graduate students, under direction, in order to arrive at some estimate of the system of management and feeding of dairy stock in the Island. This has not been confined to herds run on a commercial basis, but naturally more information has been gleaned from that type of herd because of the existence of written records. These enquiries have centred on the rations supplied, the forages used and the amounts, the method of feeding and of presentation of the feed. They also are directed to finding out the breeding efficiency of dairy cows kept in commercial dairies, with all the information cognate thereto. An attempt is being made to trace the cause of deferred conception or partial sterility, and it is hoped to test the value of artificial insemination.

Fundamentally, digestibility coefficients for various fodders have been determined, the determinations continue, and will be repeated in the future. A problem presented by the extreme wetness, or weakness in dry matter, of materials used as green fodders especially in the more rainy months needs much more study. In the drier months it is possible rapidly to wilt this fodder sufficiently to reduce the moisture by 40 to 50 per cent. and thus raise dry matter per 100 lbs., but at this time the dry matter in the fodder is higher. Whether it will pay partially to dry, or wilt artificially fodders cut and used in the wet season must naturally await examination.

It must I think be recognised that simply by tightening up in the general management economies can be effected, and that to such improved management, more minute information regarding fodders and foodstuffs, can make a further contribution.

Of course, nowhere in the West Indies, is there a station equipped to undertake research of this nature ; using the feasible forms of livestock such as the dairy cow, pig, sheep, goat, rabbit and chicken. And it is suggested that some endeavour should be made to fill in this need.

Another point of the very greatest importance, is the determination of the most prevalent and adverse forms of worms and other parasites and the general adoption of measures, not designed merely to rid animals of such infestation, and to control its severity, but to obviate as far as is possible the original and subsequent infection of the animal. The list of worms, &c., recovered from carcases, examined in the Island, is already long and impressive.

Enough I think has been written to show the need for careful research, experimental work and trial on an aspect of farming which must come much more to the forefront in the future. It is not generally recognised that a flourishing livestock industry has a great contribution to make, not only to the wellbeing of the people of the West Indies, but also to other purely agricultural industries like that of cacao, citrus, and food crop production.

FIELD EXPERIMENTS ON SUGAR CANE IN TRINIDAD.

Annual Report* for 1940.

By P. E. Turner.

Sugar Agronomist to the Department of Agriculture and Sugar Cane Investigation Committee of Trinidad.

This comprehensive Report, which contains much information of both scientific and practical value, and which comprises 260 pages, follows the main lines of the corresponding Report for 1939.† It is divided into eight sections (1) Ground Limestone, (2) Sulphate of Ammonia, (3) Potash, (4) Phosphate, (5) By-products as Manures, (6) Cultural Methods, (7) Planting Methods, and (8) Varieties. In each section the effects of the various treatments or varieties on yield of cane, on quality of crop, and on yield of sugar are fully considered. At the end of the Report the general conclusions to which the experiments give rise are summarised with special reference to soil type. Experimental layouts enabling orthodox use of the Analysis of Variance have invariably been used. Whenever possible the number of treatment replicates has been large to give the maximum degree of quantitative precision to the data obtained.

The results obtained by the author from the permanent manurial experiments with lime, nitrogen, potash, phosphate and pen manure on three contrasting soil types‡ (*Washington silty loam, Devenish Series* and *Ste. Madeleine clay*), and from the experiments on a wide range of soil types with varieties of sugar cane recently introduced into Trinidad, are of particular interest and with them this review is concerned. Reference should be made to the original Report for the information given by the large number of temporary manurial, cultural and other experiments.

On an area of *Washington silty loam* a single dressing to the acre of 10 tons of finely ground limestone (equal to the lime requirement of the soil) has been found to give rise to an average total gain in yield of more than 50 tons of cane over the seven successive crops which have been harvested. The average gain in yield of sugar from the dressing amounts to 1.26 tons for the sixth and seventh crops alone. On an area of the *Newland Series* a single dressing of coarser limestone has been found to give rise to an average total gain in yield of rather more than 20 tons of cane over eight successive crops. The average gain in yield of sugar for the sixth, seventh and eighth crops amounts to 0.97 ton. The accuracy of the method elaborated by the author for measurement of lime requirement* is illustrated by the experiment on the *Newland Series*, which showed at first little difference between the gains from dressings equal to the lime requirement and one-and-a-half the lime requirement but in which a difference in favour of the larger dressing is becoming more evident as successive crops are reaped. Particular attention has been paid to the effects of other manures on the gains from lime in these experiments. For example, on the *Washington silty loam* the residual gain in yield of plant sugar (1939 crop) and of ratoon sugar (1940 crop), from the single dressing of ground limestone applied in 1930, was found to fall from 1.81 tons to 0.20 ton and from 0.71 ton to 0.14 ton, respectively, with increase in the size of dressing of sulphate of ammonia from nil to 11¾ cwts. to the acre. The earlier work of the author† has shown that this adverse effect of sulphate of ammonia on the gain from lime can be counteracted, at least in part, by the appropriate use of water-soluble phosphate. On the *Newland Series* small dressings of potash have been shown essential to obtain maximum gain in yield of plant and ratoon cane and sugar from lime. On this *Series* it has also been shown that these dressings of potash can nullify the adverse effect of lime on the quality of the crop. The Report should be consulted for information concerning effects of phosphate and pen manure on the gain which results from liming.

On an area of *Ste. Madeleine clay*, a soil type acid in reaction and very deficient in humus, annual dressings to the acre of 3 cwts. sulphate of ammonia (shown in the Report to be the optimum size of dressing for this soil type) have been found to give rise to an average gain of 8.02 tons cane and of 0.93 ton sugar per crop over eight successive crops. There is no evidence to support the view that the beneficial effect of sulphate of ammonia on yield of cane or sugar diminishes as a result of continued annual treatment of successive crops with this fertiliser even though organic matter is never applied and each crop is burnt before harvesting. The results of a corresponding permanent experiment on the *Washington silty loam*, in which there are applied annual dressings of sulphate of ammonia exceeding half a ton to the acre, lead to a similar conclusion.

Data are recorded in the Report for the development with successive crops of response to treatment with potash on the *Washington silty*

* Copies of this Report may be obtained on application to the Author, Sugar Cane Investigation Committee, Department of Agriculture, St. Clair, Trinidad, B.W.I.

† *Tropical Agriculture*, (1940), Vol. XVII, No. 2, pp. 25-26.

‡ A description of the soil types is given in *A Preliminary Survey of Soil Types of Sugar Estates of Trinidad with special reference to the Allocation of Sugar-Cane Varieties* by P. E. Turner and C. F. Charter.

* *Soil Science* (1930), Vol. XXX, No. 5, pp. 349-381.

† *Tropical Agriculture* (1935), Vol. XII, No. 11, p. 301.

loam. On this soil type the average gain to the acre from potash has been shown continuously to increase from 1.13 tons cane for the first crop reaped on the experimental area to 9.82 tons cane for the sixth crop. Precise measures of the effects of size of dressing of sulphate of ammonia and the presence or absence of lime on the gains from potash are recorded. On the acid sandy soils of the *Newland Series*, which are deficient in humus and overlie infertile clay, treatment of each of six successive crops with 1 cwt. potash to the acre has given rise to an average total gain in yield of 28 tons cane, and there are no indications that the beneficial effect of the inorganic potash is diminishing with time in the absence of organic manures.

On areas of *Washington silty loam* and *Newland Series* only small and occasional gains in yield have been found to result from dressings of water-soluble phosphate to successive crops. On *Ste. Madeleine* clay more consistent beneficial effects have resulted from the continued use of small amounts of phosphate.

Two dressings to the acre of 20 tons of pen manure have been found to give rise to total gains in yield of 33 tons of cane in the absence of inorganic manures, and of only nine tons of cane in the presence of inorganic manures, over seven successive crops on the *Washington silty loam.* The rate of gain in yield from increasing dressings of pen manure is shown to diminish rapidly when the amount applied exceeds ten tons to the acre. Three dressings to the acre of 20 tons of pen manure have given rise to a total gain in yield of 25 tons of cane over eight successive crops on an area of the *Newland Series.* The trend of the data throughout this Report and the earlier Reports supports the view which has been held for many years by the author that organic manures are not essential in the husbandry of sugar cane provided that inorganic manures are used with understanding.

Thirty-one different varieties of sugar cane, the majority of which have recently been introduced from Barbados, India, British Guiana, the United States, Puerto Rico, Java and Fiji were under trial on some ten representative soil types in experiments reaped in 1940. Five of these varieties show great promise. The variety P.R. 803 from Puerto Rico (which has been found resistant to froghopper damage) may replace the standard variety B.H.10(12) on some of the more fertile soil types which are subject to froghopper attack. The varieties B.34104 (which has been found susceptible to froghopper damage) and B.3439 (the reaction of which to froghopper attack is not yet known) from Barbados may supersede B.H. 10(12) on more fertile soil types which are not subject to froghopper attack. B.34104 and B.3439 also give promise of supplanting B.H. 10(12), Co. 213 and Uba on soil types of intermediate and low fertility. The varieties Co. 419 and Co. 421 are competitors of B. 34104 and B. 3439 in replacing the standard varieties Co. 213 and Uba on soil types of low fertility.

MINERAL NUTRITION OF PLANTS.

The 1,000 dollar prize of the American Association for the Advancement of Science has been awarded to Dr. D. I. Arnon of the University of California for a paper read at the Philadelphia meeting of the Association on behalf of a seven-man laboratory team under the guidance of Professor D. R. Hoagland. Since Professor Hoagland's first experiments upon the mineral economy of *Nitella*—where it was shown that the growing cell swept most of the ions out of the surrounding medium, piling them up within its own sap, although thus doing work in accumulating them against the concentration gradient, whilst the mature or senescent cell indicates its advancing age by an inability even to retain or maintain this internal solute concentration—the workers in Professor Hoagland's laboratory have rapidly established quite a new conception of the mineral nutrition of the higher plant. This has thrown a new light upon the high concentration of mineral ash in growing tissues and has thus made clear to agriculturist, and still more to horticultural and forest botanist, what large reserves of minerals may be available in adult regions of the plant, to be utilized over again after release and transfer from adult to growing regions.

Prominent in this work has been Dr. F. C. Steward, working first at the University of Leeds and later at Birkbeck College, London. In some of this work, a technique has been employed with great success of introducing a new ion, bromine, and following the conditions governing its absorption and distribution. Dr. Steward has also shown, by his studies at the Tortugas, that the students of the salt accumulation of the large cells of *Valonia* cannot afford to neglect consideration of its growth phases, or of the conditions under which it is maintained during the period of the experiment. He has also advanced our general knowledge of salt accumulation by his utilization of spectrometer methods which permit a rapid quantitative control of the rates of ionic interchange. Dr. Arnon himself has contributed particularly to our knowledge of the conditions governing the relative utilization of ammonium and nitrate sources of nitrogen; he has also been associated with a series of investigations upon the significance of relatively rare elements in plant nutrition, such as copper, zinc, manganese and molybdenum. Altogether, the work recognized by the American Association in this award represents a contribution which stands very high in the esteem of plant physiologists and in which the English contribution, associated with Dr. Steward and his collaborators, reaches the same high standard, both of experimental technique and critical interpretation. —(*Nature*, 1941, Vol. 147, p. 292.)

CROP PRODUCTION IN ARTIFICIAL CULTURE SOLUTIONS AND IN SOILS.*

(With Special Reference to Factors influencing Yields and Absorption of Inorganic Nutrients).

DURING the past decade, great interest has been aroused in the use of artificial media (water, sand and gravel cultures) for crop production and in their commercial possibilities. Many interesting questions have arisen, such as: How do the inherent productive capacities of a fertile soil and nutrient solutions compare? What factors limit crop production in a fertile soil, and can they be controlled in artificial media? How do they compare as to water economy? Can the mineral composition and vitamin content be influenced by the nutrient medium?

Two experiments are here reported dealing with these questions, extending over a year, and using the tomato as test plant. Soil, sand and nutrient solution cultures were used, with plants similarly spaced, and receiving the same cultural treatments. The tanks were 10 by 2.5 feet in area, and contained twenty plants, raised under similar conditions, and planted out at eight weeks of age. Plants in the water culture were supported on a porous bed of rice hulls. In the soil culture, a clay-loam, manured as for successful commercial production, was used. As heated solutions had been reported to be associated with high yields, heated cultures of each of the three media were included, the temperatures being 20° C in the full-winter experiment, and 23° C in the spring-summer experiment.

In the spring-summer experiment, forced aeration (from sintered glass aerators, one to each plant, giving a fine stream of bubbles) was used, in addition to aeration by the usual method of lowering the nutrient solution, and using a porous litter cover, permitting diffusion. A check was kept on the water supplied to each culture.

EXPERIMENTAL RESULTS.

It is commonly believed that artificial media have a much higher inherent productive capacity than soil, even under favourable conditions, but this view has not been supported by direct quantitative comparison. The experiments reported compared soil and artificial media, under the same conditions, using spacing reported to give high yields for water culture. The yields (of tomatoes) obtained were equal to the highest yet reported (352 lb. per 25 square feet), the soil yielding 358 lb. and the water culture, 402 lb. per 25 square feet. No evidence could be found to support the view that water culture is vastly superior to a well-managed soil. Generally, fall-winter yields were the lower, light evidently limiting growth. Heating the culture did not have any marked effect on yield.

INFLUENCE OF AERATION.

It has been found, contrary to some opinions, that the oxygen supply to roots, in water culture without forced aeration, is sub-optimal. Using forced aeration and a porous litter cover to the tanks, the following yields were obtained:—

Solution unheated	15.7 lb.
Solution unheated but aerated	21.1 lb.
Solution heated	17.0 lb.

Forced aeration was associated with an increase in both vegetative vigour and yield. Aeration gave an appreciable increase over unaerated cultures, whether heated or not. At the conclusion of the experiment, the roots were cut, dried and weighed, the weights in grammes per plant being:—solution unheated, 12.4 g.; solution unheated but aerated, 19.9 g.; solution heated, 14.6 g. This illustrates the favourable effect of aeration on root growth. Thus, aeration proved to be a limiting factor, even when the plants were grown with a porous cover and a lowered level of nutrient solution. Heating gave only a small increase in yield, suggesting that oxygen supply, rather than temperature, determined maximum growth under the prevailing light conditions. The heated sand-culture gave a higher yield than the soil, which suggests that the plants could profit from a more liberal oxygen supply than that provided by the soil. The high yields obtained from the soil shows that it actually provided very good aeration for the roots. It is suggested that the more rapid removal of carbon-dioxide may have been a beneficial factor.

WATER ECONOMY.

The amount of water required to produce 100 pounds of fruit did not differ greatly in soil and water-cultures, being around 220 and 265 gallons respectively. Since growth in either medium was comparable, this result supports the view that the chief water-loss is due to transpiration, determined by climate and by the amount of transpiring surface.

ABSORPTION OF MINERAL NUTRIENTS.

Regarding the uptake of mineral nutrients from the solutions, it was found that heating gave an increase in uptake, and that a marked increase resulted from aerating the unheated solution suggesting that, under the conditions of the experiment, aerating the solution was more important than heating it. These facts support the view that active salt accumulation is dependant on the metabolic activities of the cells. Injurious effects may be attributed to relatively high temperatures around the roots, leading to excessive metabolic activity. Potassium and nitrogen were absorbed in high quantity throughout growth, their uptake falling off slightly towards the end of the experiments. Phosphate, calcium and magnesium were not so important when regarded on a quantitative basis.

* Paper by D. I. Arnon and D. R. Hoagland, published in *Soil Science*, Vol 50, No. 6, 1940, pp. 463-485.

Discussion.

Is there an optimal nutrient solution ? Plants raised under natural conditions, and growing in various kinds of soil, are not rooted in nutrient media of fixed composition, but the composition of the media varies with soil and season. Suggestions have been made that the soil or culture solution should reflect the "average" composition of the plant, and that there should be a "balance" between nutrients. The actual need would appear to be, however, that there should be at each stage of growth a *sufficient quantity* of each essential nutrient element.

Plant composition is in part genetically determined, and is also influenced by climatic factors. Different plants growing in the same medium develop tissues having different mineral compositions. Nutrient solution can affect composition, within limits, and the analyses of the plant may therefore not be an accurate basis for formulating a nutrient solution. It seems therefore that there is no "best" solution. This conclusion is supported by the satisfactory results obtained by different workers using different solutions. The nutrient solution should be one which can be conveniently managed to ensure an adequate supply of nutrients. Owing to the differential absorption rates of nutrients by the plant, it is difficult to maintain the initial composition of the solution unless large volumes are used, or the solution is continuously renewed. In these Californian experiments, analyses were made, and the necessary amounts of nutrients based on them were systematically added. It would be convenient if they could be added in the proportions utilised by the plant, so that they could be added collectively. The maintaining of the pH of the solutions on the acid side of neutrality is important in order to prevent precipitation of minor elements, such as iron. The writers found the range pH 4.5 to pH 6.5 to be very satisfactory. The solution used in the experiments had the composition: KNO_3, 0.010 M; $Ca(NO_3)_2$, 0.003 M; $MgSO_4$, 0.002 M; and $NH_4H_2PO_4$, 0.002 M, and was found to be adequate. Boron and manganese are generally added to nutrient solutions, but the other micro-nutrients are usually present in sufficient quantity as contaminants.

Large- *versus* Small-scale Water Culture.

There seems to be no evidence against using the principles of small-scale scientific experimentation in commercial practice. Any changes in technique are determined by the scale of operations and by economic considerations. Such changes would include the use of commercial chemicals, tap water, and sturdy watertight containers not toxic to plants. It must be borne in mind that water culture does not alter such requirements as light, temperature and length of day, and these factors should be carefully considered for each crop. The experiments show that it is possible to produce on a large scale as good crops from water or sand culture as from the best soils under similar climate. The chief considerations are economic and limit the method to the production of highly-priced greenhouse crops. Water-culture or sand-culture could not compete in cheapness with the conventional methods of agriculture involving natural soils. Another consideration concerns the nutrient solution which, even though it may supply sufficient nutrients for several closely-spaced crops, the amount supported will depend primarily on the availability of the light in a given area.

Comments on Factors Limiting Yields.

The most important consideration is that no change in the nutrient solution can compensate for a deficiency in climatic environment and give an increased yield. In the experiments, it was found that spring yields were over twice as large as the winter yields, because of the dominant influence of light, since all other conditions were unchanged. Regarding the nutrient medium itself, the increase from forced aeration was particularly well marked, and it seems doubtful that even the best soil could supply oxygen to the roots as fast as an artificially-aerated culture solution is able to supply it. In addition, the question of carbon-dioxide removal is important, and it appears from the experimental results that aeration (or associated carbon-dioxide content) may limit growth of certain crops even in a highly manured soil. Tomatoes possess a high aeration requirement, and, in the case of crops with lower requirements (such as cereals), aeration seems to be less important. The improvement in aeration in artificial nutrient media, compared with that in natural soils, may constitute an inherent advantage for the growths of certain crops.

Plants appear to be able to synthesise their own growth substances, and the need for organic components in the media for the growth of higher plants, has not been satisfactorily demonstrated.

The interpretation of nutrient solution data in terms of soil is difficult, because of contact effects between roots and soil colloids. In the case of calcium and nitrate, the soil solution must be an important immediate source of supply, but in the case of potassium and phosphate, the concentration in the soil solution may be so low as to limit the uptake of these nutrients to absorbed ions associated with the soil colloids and liberated to the root by ionic exchange. On the other hand, the concentration of potassium occurring in the soil solution, sufficient to support good plant growth, has been found to be about equal to that successfully used in nutrient solution cultures. Concentrations of phosphate in the soil solution may be so low, however, that the absorption of this nutrient cannot be accounted for by direct uptake from the soil solution.

It seems that, under greenhouse conditions, heavily-fruiting plants cannot be developed when the potash or phosphate concentration in either artificial media or soils is relatively very low.

It is necessary to differentiate clearly the comparative importance of the concentration and the *total supply* of plant nutrients occurring in a culture medium. The volume of the medium accessible to the roots should also not be disregarded. This was well illustrated in experiments with a soil having low potassium availability, in which the appearance of potassium-deficiency symptoms, within a limited time, depended entirely on the size of the container.

It is interesting to note that the presence of large amounts of available nitrogen in the nutrient media did not cause a dominantly vegetative habit of growth, in spite of the fact that nitrogen was present to the full absorption capacity of the plants. This result may be attributed to the very favourable light and temperature conditions obtaining during the day, and to low night temperatures, conducive to conservation of carbohydrates. Finally, it appears that there is no great difference in the inherent productive capacity of good soil and culture solutions. Aeration, it is suggested, may limit production in some soils, even with an adequate water and nutrient supply. The great importance of adequate soil aeration is particularly indicated by the most important series of experiments which the authors of this interesting paper have been able satisfactorily to conclude.

H. A. McK. T.

REVIEWS.

A SURVEY OF INSECTICIDE MATERIALS OF VEGETABLE ORIGIN.

Imperial Institute, London (edited by H. J. Holman), 1940, viii + 155 pp., 3*s*. 6*d*. net.

This is a valuable summary on the production and use of insecticides of vegetable origin. The cultivation of the crops, the marketing of the raw and manufactured products and their consumption are treated in considerable detail, with statistical data from many countries, and there are also descriptions of the chemistry of the insecticides and of their application and action on insects. Part I deals with alkaloid-containing materials, chiefly nicotine and a few minor insecticides such as anabasine and hellebore. Part II is devoted to the numerous plants containing rotenone and allied compounds, of which the most important are species of *Derris* and *Lonchocarpus*. Part III is on pyrethrum and there is a brief account of quassia and plant oils. Much of the information is gathered from sources which are not readily accessible to either the agriculturist or the entomologist.

In the Introduction there is a brief but valuable discussion of the future of the plant insecticides. In spite of their great number and variety and the advantage they possess in being relatively harmless to man and to plants, they have not yet fulfilled their promise of replacing the dangerous arsenicals, which still hold the field as the most widely used insecticides. Two of the chief obstacles are the instability of many of the vegetable products and the difficulty of preparing them in highly standardised form. These disadvantages are being overcome, and extensive researches are being conducted on improvements in the preparation of the known vegetable products and on the development of new substances. At the same time advances are being made in the manufacture of synthetic insecticides. "It is thus necessary to sound a note of warning, and to emphasize that synthetics are likely to become increasingly competitive in this field. There is, however, another side to the question. The addition of a synthetic material to an insecticide of plant origin may enhance the value of the insecticide as a whole, and thus bring about an increase in demand for both synthetic and plant insecticides."

A. M. A.

* * *

INSECT TRANSMISSION OF PLANT DISEASES.

By J. B. Leach. McGraw-Hill, New York and London, 1940, xviii + 615 pp., 238 figs., $6.

This is one of the best and most important works that have appeared in the fields of agricultural entomology and plant pathology. It is the first book on its subject, which is of immense importance, and it will undoubtedly remain the standard work for a long time. The innumerable ways in which insects cause infections in plants are surveyed in great detail, with a wealth of illustrative examples, but the author maintains a critical attitude throughout, showing where further investigations are required, and emphasising the general principles involved in the facts he presents. The subject is treated from the widest standpoint. There are interesting chapters, for example on the interrelations of insects and plants; symbiosis between insects and microorganisms; the anatomy and physiology of both plants and insects; the effect of toxins injected by insects; a comparison between animal and plant diseases as transmitted by insects. The numerous illustrations and the form of the book are excellent.

Most of the researches which form the subject matter of this book have been conducted in temperate regions. The author has not, however, neglected what is known about the rôle of insects in diseases of tropical crops, and gives appropriate space to such diseases as internal boll-rots and leaf-curl of cotton, mosaic and Fiji diseases of sugar cane, and the streak and stripe viruses of maize. But it is apparent that comparatively little is known about insect transmission of plant diseases in the tropics.

A. M. A.

RESOURCES OF MANURIAL SALT-ORES IN THE BRITISH EMPIRE.

The following information has been abstracted from the text of the Twenty-third Streatfeild Memorial Lecture for 1940, delivered by Sydney J. Johnstone, Esq., of the Imperial Institute of London, and published by the Institute of Chemistry in March, 1941. The data refer, of course, solely to immediate pre-war conditions, mainly up to the end of 1938.

Nitrates.

The term nitrates includes natural sodium nitrate (Chile saltpetre), potassium nitrate and various manufactured compounds, *e.g.* nitrate of lime, nitro-chalk, sodium nitrate, &c. Their principal uses are in the manufacture of nitric acid and ammonium nitrate for explosives, and for fertilisers.

The Empire does not possess nitrate deposits comparable with those of Chile, but some occurrences serve local needs and provide a small exportable surplus.

India has an annual output of about 9-10,000 tons of nitrate of potash, obtained by extracting the earth of old village sites. In 1938-9 the chief production came from the Punjab (5,109 tons), the United Provinces (2,275 tons) and Bihar (1,324 tons). A small quantity is used locally on tea plantations, but most of the nitrate is exported.

The United Kingdom imported in 1938:—nitrate of soda, 46,212 tons; nitrate of potash, 2,460 tons; and nitrate of lime, 5,116 tons.

Phosphates.

The principal natural phosphates used commercially are rock-phosphate (chiefly calcium phosphate) and apatite (calcium phosphate with some calcium fluoride or chloride). They are used chiefly in the manufacture of fertilisers such as super-phosphate, as source of phosphorus and phosphates, and to a less extent in stock and poultry feed and in the smelting of certain iron ores. Basic slag, a valuable phosphatic fertiliser, is a by-product of the basic iron and steel industry.

Phosphorus compounds, chiefly the metaphosphates, are employed in laundry work, in softening boiler-feed water, and in food preparation. Phosphorus enters into tracer bullets, flares and smoke screens.

The principal sources of supply of Empire phosphates are Nauru, Ocean and Christmas Islands. In 1938 the production of Nauru Island was 841,050 tons, Ocean Island 299,550 tons, and Christmas Island (Indian Ocean) 159,859 tons. More than 21,000 tons of phosphatic guano was exported from Seychelles and small quantities of phosphate minerals were produced in Canada, Tanganyika, Australia and India.

The working and allocation of the phosphate from Nauru and Ocean Islands is controlled by the British Phosphate Commission which consists of nominees appointed by the Governments of Great Britain, Australia and New Zealand, who in 1919 bought out the holders of these deposits for the sum of £3½ million. The three Governments have the right to share the production in the ratio of 42 : 42 : 16. For economic reason supplies have been taken principally by Australia and New Zealand. In 1937-38 Australia took 66.17 per cent. of the quantity exported whilst New Zealand received 24.86 per cent.

Most Empire countries import large amounts of raw and manufactured phosphates, the United Kingdom normally taking annually about 420,000 tons of phosphate rock (in addition to 15-30,000 tons of superphosphate); Australia, 600,000-800,000 tons; New Zealand, 260,000 tons (and 70-90,000 tons basic slag); and Canada 115,000 (in addition to 100,000 tons of superphosphates and 10,000 tons basic slag.) Other Empire countries take smaller amounts.

Important quantities of superphosphates are manufactured in the Empire, the chief tonnages produced in 1938 being Australia, 1,244,038; United Kingdom, 551,087; New Zealand, 408,693; Union of South Africa, 140,226; and Canada 88,519.

Potash.

The world's three principal mineral supplies of potash are obtained from (1) bedded deposits such as those of Stassfurt, Alsace and Spain where the element occurs either as the chloride, or as a double salt of potassium chloride and magnesium sulphate; (2) Seawater, brines and salt-lake deposits containing potash salts; (3) Insoluble potash minerals such as alunite (hydrated sulphate of potassium and aluminium), felspars (silicates of potassium, sodium and aluminium) and leucite (potassium aluminium silicate). The last two sources are only of minor importance compared with the first.

The use of potassium compounds in fertilisers probably accounts for about 90 per cent. of the consumption, the salts used being the chloride, the sulphate and kainite ("fertiliser salt").

Other uses for potassium compounds are in the manufacture of soap, glass, matches, and gun powder and in tanning, meat curing, &c.

The amount of potash obtained in the Empire is small, the only large sources of supply being potassium chloride obtained from the waters of the Dead Sea in Palestine and potassium nitrate obtained from India (*see* Nitrates). The estimated K_2O equivalent of the Empire's 1939 output was 32,500 tons, of which Palestine contributed 31,000 tons as compared with 28,600 tons in 1938, in addition to useful amounts of magnesium salts and bromine (q.v.). Australia is investigating a process to obtain a fertiliser salt, amongst other products, from alunite (*see* p. 30).

The United Kingdom normally imports potassium salts both in the form of fertilisers and as chemical products. In 1938 the principal quantities were; potash fertiliser salts, 62,154; chloride, 89,043; sulphate, 43,729; caustic potash and lyes, 6,445; carbonate, 3,861; nitrate, 2,460 tons.

MISCELLANEOUS NOTES.

Improvements in Rubber Planting Material.

C. E. T. Mann has recently published a paper on this subject (Comm. 251, *J. Rubber Res. Inst. Malaya*, 10), which summarizes the results of ten years' studies of specially selected clones of rubber, propagated by budding and now tapped for rubber through this period. The original selections of clones were made by Sanderson and Sutcliffe, scientific officers of the Rubber Growers' Association in Malaya, and budded on to stocks in 1924; in 1927 their further study was taken over by the Rubber Research Institute. With a perennial like Hevea, the period since 1927 only permits a tentative and preliminary estimate of improvement in yield but of the 21 clones originally selected it is now possible to say that two of the clones are first class. After searching tests and under normal tapping conditions, it can now definitely be concluded that all the trees of these clones behave similarly and show a steady development towards a yield at maturity which is almost treble that shown by the average seedling trees planted at the time the clones were first established. The results, which confirm the conclusion of research workers in the Netherlands East Indies, also stress the great value of the uniform product to be obtained from a clone, a result which should readily be accepted in the horticultural home of Cox's Orange Pippin, Ribston Pippin, &c. But Mr. Mann has to report a considerable prejudice still existing among Malayan planters against budded trees as against natural seedlings. The rubber plant will not self readily, so that it is of considerable importance that the studies of legitimate seedlings resulting from artificial crosses between high yielding clones show that such seedlings have a high average yield though the usual variability. Further selection from such material, coupled with further vegetative propagation, holds out still more hopeful prospects for the future.—(*Nature*, Vol. CXLVII, No. 3718.)

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Single and Multiple Stem Arabica Coffee.

Arabica coffee is everywhere prone to suffer from die-back as the result of early overbearing. The only way to prevent this is to head back the young bush to 80 cm. at a year old; this results in a plentiful production of leafy as opposed to fruiting shoots. In addition, the two lowest branches are removed, one of the remaining topmost ones and a few lower down if and where the internodes are unduly short. Subsequent pruning aims at maintaining suitable leaf: fruit balance. Sometimes, in spite of pruning, poor soils will cause die-back. Coffee on red laterite soils which has never fruited has been made profitable by lavish applications of compost and mulching. A correctly formed tree should have 18 pairs of primaries, regularly spaced and furnished with numerous secondary branches. The height should be from 1.30 m. to 1.50 m. In a recent recording of 20 trees secondary branches have yielded 1.8 times as much as the primaries, and the upper half of the tree, primaries and secondaries combined, produced 3.145 kg. of cherry to 2.445 kg. on the lower half. As regards shape and quality there was no difference between the bean weight and shape averages of primaries and secondaries. The average weight of the individual beans from the upper part of the bush is slightly less than for the lower half, 15.1 g. against 16.2 g. Multiple stem bushes deprived of secondaries but not cut back have excited some interest. They are simpler to prune and cultivate but their yield is less than properly cared for single stems. They are useful in districts where the excessive vegetative development affects fruiting adversely.—(Results of Experiments carried out in the Belgian Congo.) —(*Horticultural Abstracts*, X, No. 4.)

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Control of Coconut Pests in the Seychelles.

An experiment in the biological control of coconut pests in Seychelles has recently been described by Mr. D. Vesey-Fitzgerald, in the *Bull. Entomol. Res.*, 31, 1940. The pests concerned are scale insects (Coccidae), and of these, four species were specially injurious. It is noteworthy that the species in question, namely *Ischnaspis longirostris*, *Pinnaspis buxi*, *Chrysomphalus ficus* and *Eucalymnatus tessellatus*, are unknown as major pests of coconut in other countries, while the brown scales, that are common pests of this crop, are not found in the Seychelles. Other Coccidae were also found to be infesting coconut in this area, while a large variety of different species was noted as attacking the general vegetation.

During the course of the work it became evident that general rather than specialized enemies of Coccidae required searching for. Species that would, in fact, attack all the different scale insects without special preference were obviously needed, since the elimination of a particular kind might result in an increase of some other species. The life-history and special requirements of each of the four species already named, are described and their incidence on the coconut is discussed.

In order to combat these Coccidae, four species of Coccinellid beetles were introduced from East Africa. The species were *Chiloconus distigma*, *C. wahlbergi*, *Exochomus ventralis and E. flavipes*. Since the journey from Mombasa to Seychelles takes only three days by steamer, these predators could be landed there within a week of leaving the centres where they were bred in East Africa. From records covering three years it is shown that the introduced enemies are reducing the scale insects below the density at which they cause economic loss. Also it seems that the reduction of one species of pest has not been followed by a correlated increase of another species.

CHEMICAL NOTES.

(Compiled by the College Department of Chemistry and Soil Science.)

Bauxite as a Sugar Refining Adsorbent.

Bauxite, a naturally occurring hydrated oxide of aluminium, has been thermally activated to produce a highly efficient adsorbent for the refining of sugar syrups and liquors. Laboratory data indicate that the percolation of crude sugar solutions through activated bauxite raises the apparent purity three to ten per cent. in the case of syrups, and up to two per cent. for high purity liquors. The invert content of the solution is decreased to four to 34 per cent. Decreases of 20 to 80 per cent. in the ash content are observed following filtration through activated bauxite. The pH of the filtrates depends partly on the activation or regeneration temperature to which the adsorbent is submitted. The colors of activated bauxite-filtered sugar solutions are brilliant, and vary from water-white to a rich amber. The high refining efficiency of the adsorbent is maintained after repeated use. The physical properties and handling characteristics of bauxite are not radically different from the other adsorbent materials used in the sugar refining industry. Since, however, activated bauxite is entirely inorganic in composition, regeneration by heating in the presence of oxygen, after washing, is simple and rapid. Revivification may also be carried out in a close system. Plant-scale work is in progress and will be reported later.—(*Facts about Sugar*, 1940, Vol. XXXV, p. 33.)

* * *

Translocation of Minerals in Cotton.

There seems to be quite general agreement as to the tissues responsible for the movement of sugars and water in the higher plant, but the position with regard to mineral nutrients still remains somewhat obscure. Another attempt to solve this latter problem has recently been made by Phillis and Mason, using as indicators of translocation, calcium (immobile in phloem) and phosphorus (mobile in phloem) (*Ann. Bot.*, N.S. 4, 635; 1940), and bromine (*loc. cit.*, p. 651). Sea Island cotton plants were used, and in the first investigation was confined to roots, stem, and two branches by judicious removal of developing buds. In this work, one set of plants were ringed at the base of one branch. There was an initial collection of normal plants and three subsequent collections of ringed and normal plants over a period of fourteen days. Ringing caused a slight reduction of both calcium and potassium uptake in the plant as a whole, but the ringed branch itself was found to contain more potassium and less calcium than either the unringed branch or the branches of the normal group. The results are in harmony with the view that the bulk of the solutes move upwards in the wood and, provided they are mobile in the phloem, are re-exported down the stem in this tissue. Phosphorus is trapped by the ring and therefore accumulates. The effect of transpiration on mineral uptake is the subject of the second paper. The authors point out that previous attempts to separate the effects of transpiration and assimilation (leading to transport of sugars to the roots and a possible change in uptake) have been largely unsuccessful; they therefore observed plants in which the roots are isolated by a phloem ring at the cotyledonary node. After two hours exposure to light, both normal and ringed plants had absorbed bromine rapidly. While the presence of the ring had depressed slightly the uptake of bromine by the roots (below the ring), no appreciable difference was observed between the tops of the two series. Subsequent determinations on ringed plants in light and in darkness established the fact that transpiration increases uptake of bromine. It is suggested that transpiration affects uptake by altering the concentration in the absorbing region of the root (and possibly also by oxygenating the root) while assimilation is active by altering the solvent capacity of the root. Mineral nutrients thus appear to travel up the stem in the wood; whether, in normal plants, a proportion also ascends in the phloem is not yet clear.—(*Nature*, 1940, Vol. CXLVI, No. 3711, p. 779.)

* * *

Sunflower as an Indicator Plant of Boron Deficiency in Soils.

Tests under greenhouse conditions with small amounts of soil indicate that sunflowers can be successfully used as an indicator of the level of available boron in soils. The boron-deficiency is shown by a cessation of growth of the terminal bud, reduced dry weight, and abnormal leaf characteristics. When small soil samples are used in the greenhouse, boron-deficiency can be corrected by adding 1 to 2.5 p.p.m. of boron to the soil. Humus depletion seems to aggravate boron-deficiency and the addition of an adequate amount of compost to the soil corrects the deficiency. Available-boron is usually greatest in the upper 3 feet of soil. Below 3 feet the shortage is often extreme. Boron-deficiency may be over-shadowed by other deficiencies. Adequate amounts of available basal nutrients make possible sufficient plant growth so that boron-deficiencies quickly become evident.—(*J. Am. Soc. Agron.*, 32, 607-21.)

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Mineral Deficiency and Cattle Raising in British Guiana.

Analyses show that the pastures on the higher lands of the Rupununi and Berbice savannas are valueless for grazing because of the extreme lime and phosphate deficiencies. Figures for grass at different stages of growth indicate that there is no definite drop in the contents of lime and phosphate up to 6 weeks of age, but the nitrogen content of the youngest grass is much higher than that of the older grass.—(*Agr. J. Brit. Guiana* 10, 194-204.)